LECTURE 30: Beat frequency
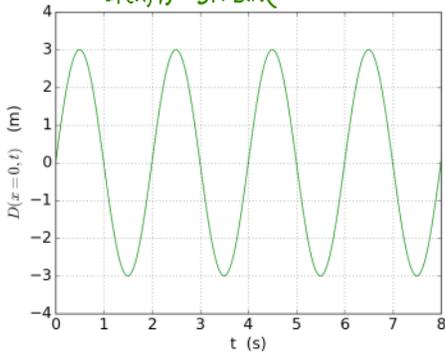
TEXTBOOK CHAPTERS:

- Ginacoli ((Physics Principles with Applications 7th) :: 12-6
- Knight (College Physics : A strategic approach 3rd) :: 16.7
- Boxsand :: Beats

WARM UP: When analyzing standing waves, what feature of the wave should you identify first before applying any mathematical description?
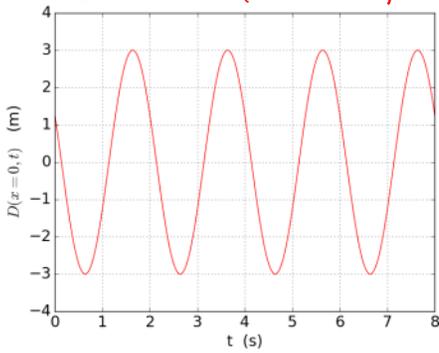
We saw that when two waves enter the same region of space at the same time, the waves interfere. The interference is mathematically modeled by the superposition principle (i.e. waves add linearly, point by point at each instant in time). So far we have discussed waves with the same frequency interfering with one another. We did a case study on this type of interference when studying standing waves. Standing waves are known as a spatial interference. In other words, you would need to walk through space from one location to the next in order to observe the constructive and destructive interference patterns. The constructive and destructive interference patterns were located at fixed regions of space. If you stood at a constructive interference location you would always hear a louder sound compared to if there was only one source of sound. In this lecture we will explore a different type of interference that is classified as temporal interference. You do not have to move through space to observe temporal interference. For example, if you stand at a fixed location in space you will hear loud and quite sounds that oscillate back and forth; at any one instant of time you might hear constructive interference (loud), and at some time later you would hear destructive interference (quite). One way to produce this type of temporal interference is by using two sources with different frequencies. Below is a comparison of spatial and temporal interference patterns.
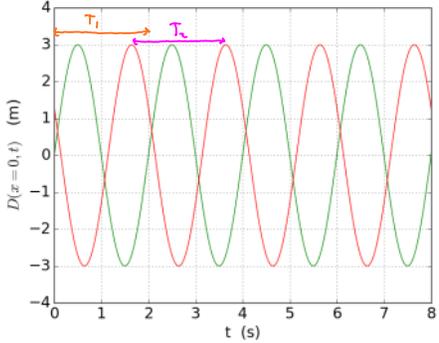
SPATIAL INTERFERENCE

$D_1(x,t) = 3m \, Sin\left(\frac{\pi}{2}x - 2\pi t\right)$ TRAVELS TO RIGHT @ v

TEMPORAL INTERFERENCE

$D_1(x,t) = 1.5m \, Sin\left(\frac{\pi}{2}x - 4\pi t\right)$ TRAVELS TO RIGHT @ v

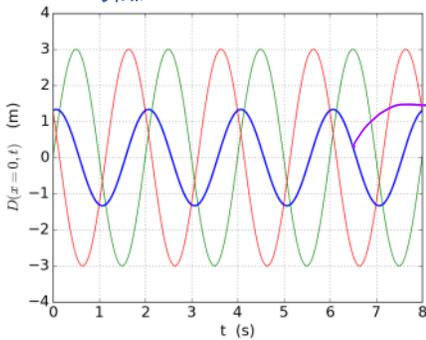$D_2(x,t) = 3m \, Sin\left(\frac{\pi}{2}x + 2\pi t + \frac{\pi}{7}\right)$ TRAVELS TO LEFT @ v

$D_2(x,t) = 1.5m \, Sin\left(\frac{5}{12}\pi x - \frac{10}{3}\pi t\right)$ TRAVELS TO RIGHT @ v

BOTH TRAVELING WAVES HAVE SAME f

$f_1 = \frac{1}{T_1}$

$f_2 = \frac{1}{T_2}$

$T_1 = T_2$

SO
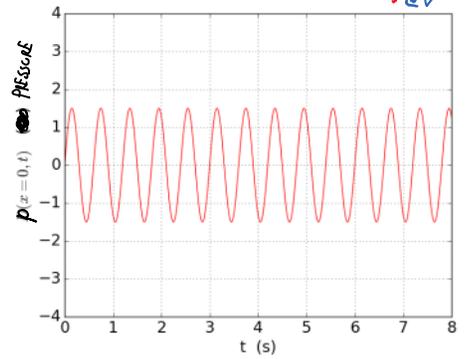
$f_1 = f_2$

THE TWO TRAVELING WAVES HAVE DIFFERENT FREQUENCIES

$f_1 = \frac{1}{T_1}$

$f_2 = \frac{1}{T_2}$

$T_1 \neq T_2$

SO $f_1 \neq f_2$
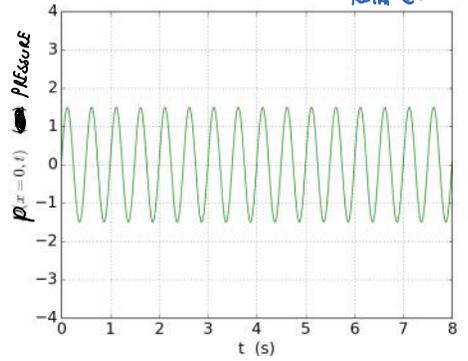
$D_{TOTAL} = D_1(x,t) + D_2(x,t)$

AT X=0 YOU WOULD HEAR A SOUND OF CONSTANT FREQUENCY BUT SOFTER THAN IF ONLY ONE WAVE EXISTED.

BEAT FREQUENCY

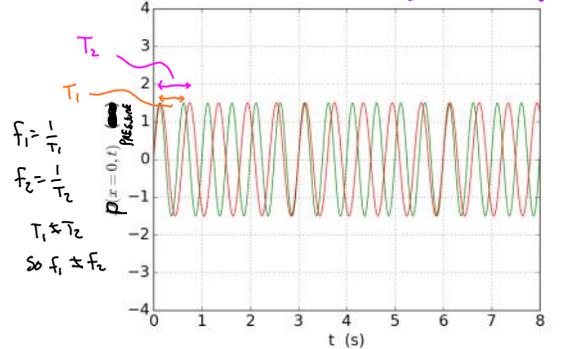BEAT PERIOD.... $f_B = \frac{1}{T_B}$

T_B

LOUD   SOFT   LOUD   SOFT   LOUD   SOFT
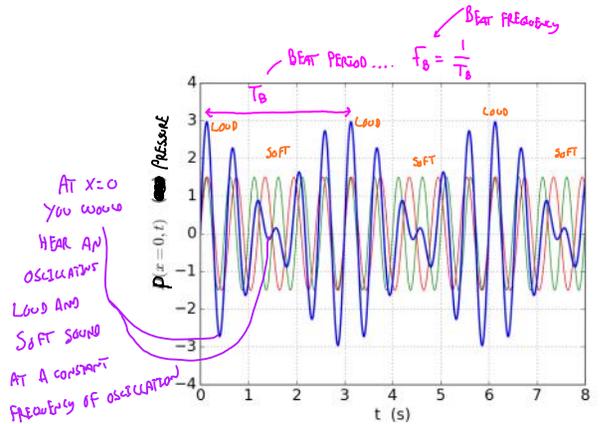
AT X=0 YOU WOULD HEAR AN OSCILLATING LOUD AND SOFT SOUND AT A CONSTANT FREQUENCY OF OSCILLATION

Mathematically we can calculate this beat frequency by the equation below.

$$f_B = |f_1 - f_2|$$

PRACTICE: A tuning fork of frequency 440 Hz is struck. Next to this tuning fork another one with a frequency of 444 Hz is struck. What is the beat frequency head when the two play together.

(a)   436 Hz
(b)   448 Hz
(c)   4 Hz
(d)   8 Hz

PRACTICE: Two identical strings are adjusted to vibrate at exactly 240 Hz. The tension in one string is changed slightly and afterward three beats per second are heard when the two vibrate at the same time. What happened to the adjusted tension?

(a)   Increased
(b)   Decreased
(c)   Impossible to determine

QUESTIONS FOR DISCUSSION:

(1)   Explain how beat frequencies and guitars are related. What might you use beat frequencies for on a guitar?
(2)   Are beat frequencies always audible?